IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

Enhancing nuclear safety

Update of the Nuclear Criticality Slide Rule for Emergency Response to a Nuclear Criticality Accident

Matthieu DULUC, Aurélie BARDELAY, Dave HEINRICHS, Calvin HOPPER,
Richard JONES, Soon KIM, Thomas MILLER and Chris WILSON

NCSP
NUCLEAR CRITICALITY SAFETY PROGRAM

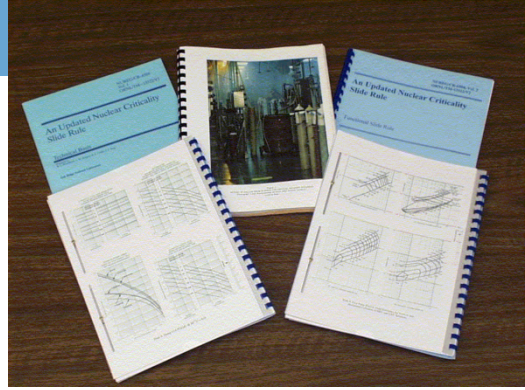
IRSN INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

OAK RIDGE National Laboratory

AWE

March 15, 2016
Sandia National Laboratory

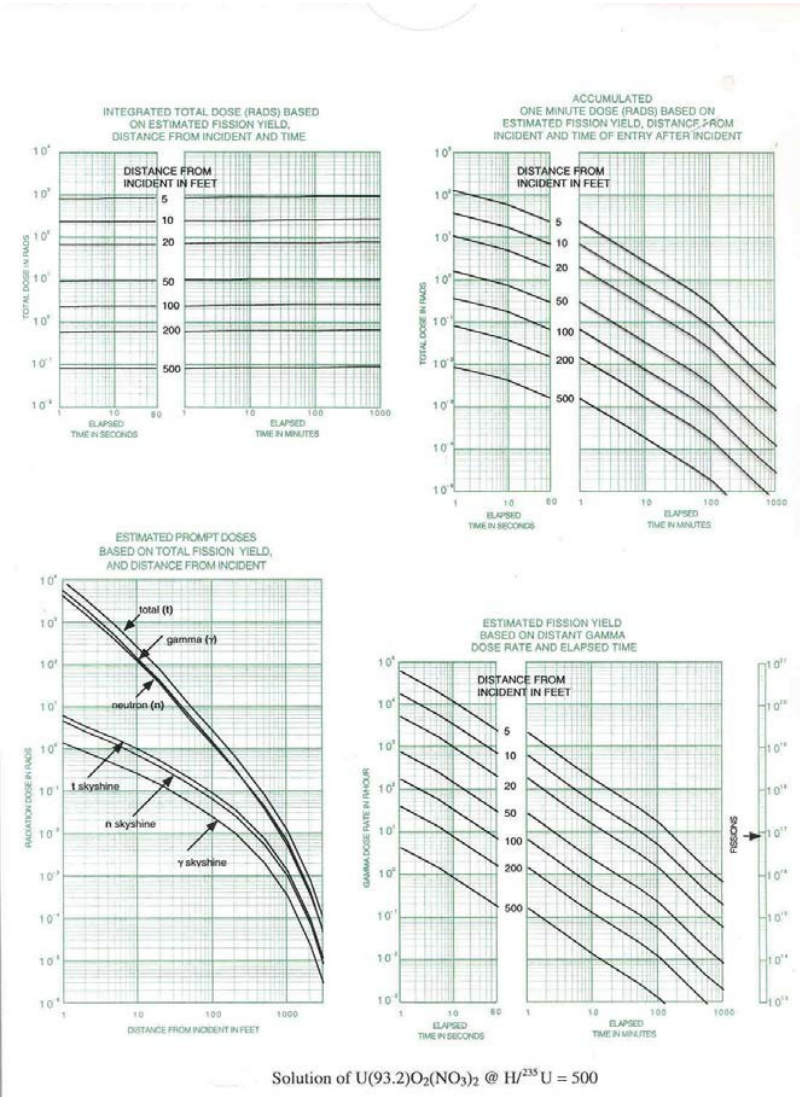
Slide Rule ?



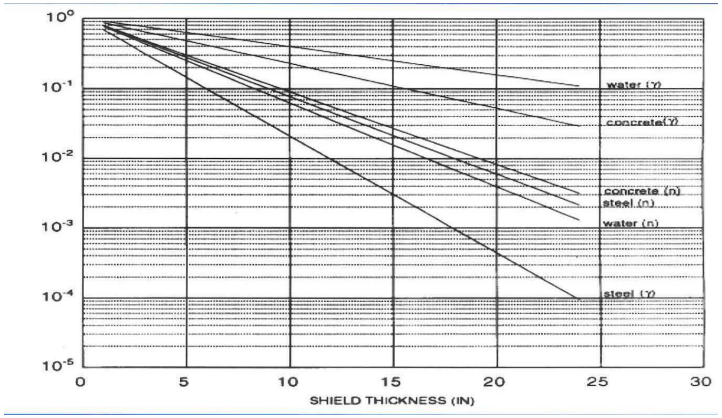
- April 1997, An Updated Nuclear Criticality Slide Rule
  - ORNL/TM-13322/V1 & V2: Technical Basis / Functional Slide Rule

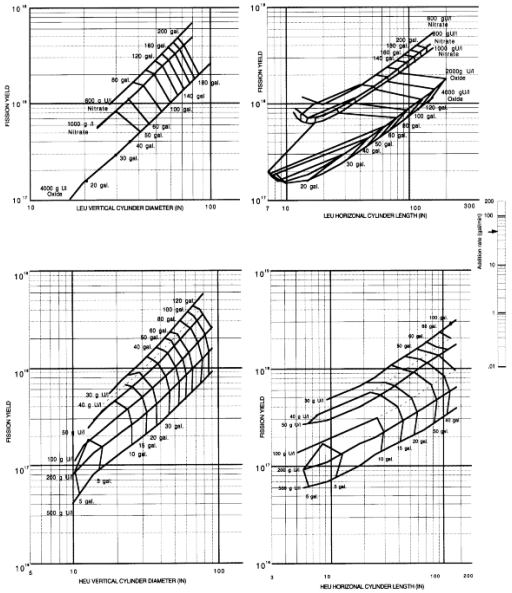
- This document gives order of magnitude estimates of key parameters, useful for emergency response teams and public authorities:
  - The magnitude of the number of fissions based on personnel or field radiation measurements or various critical system parameter inputs,
  - Neutron- and gamma-dose at variable unshielded distances from the accident,
  - The skyshine component of the dose,
  - Time-integrated radiation dose estimates,
  - One-minute decay-gamma radiation dose,
  - and dose-reduction factors for variable thicknesses of steel, concrete and water.

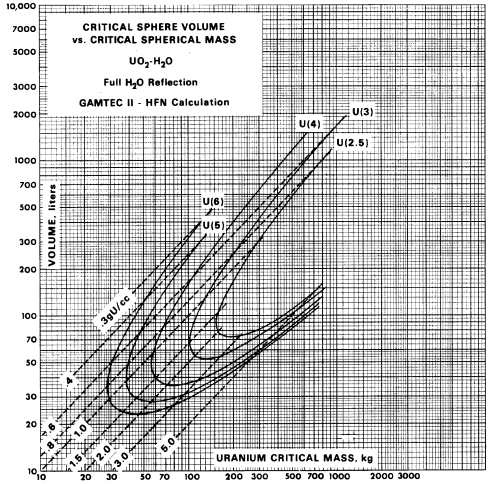
US Slide Rule



Solution of $U(93.2)O_2(NO_3)_2$ @ $H/^{235}U = 500$

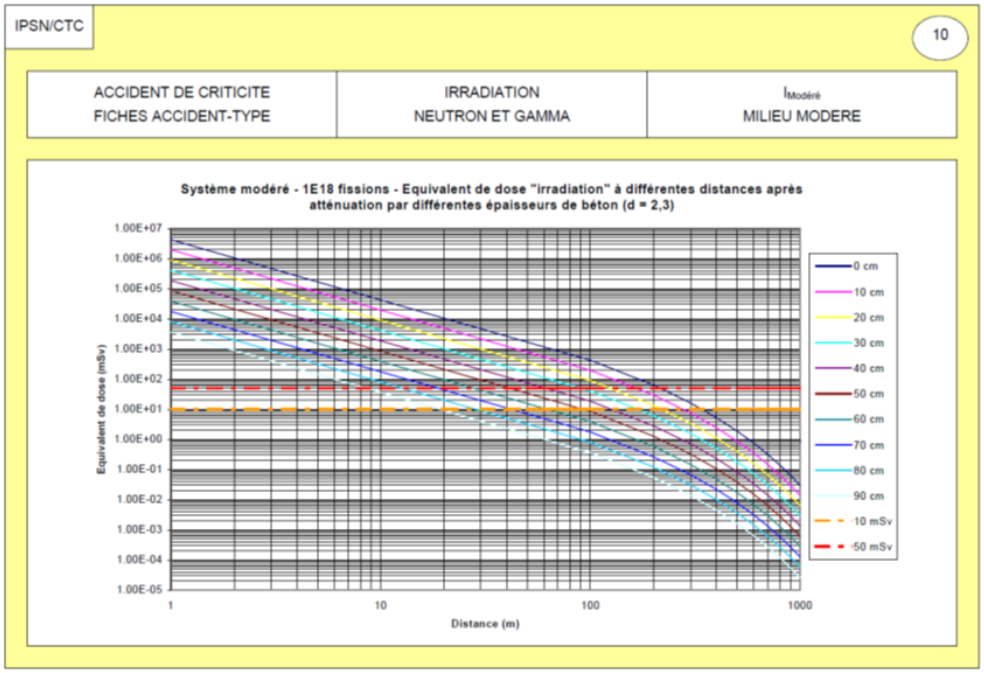




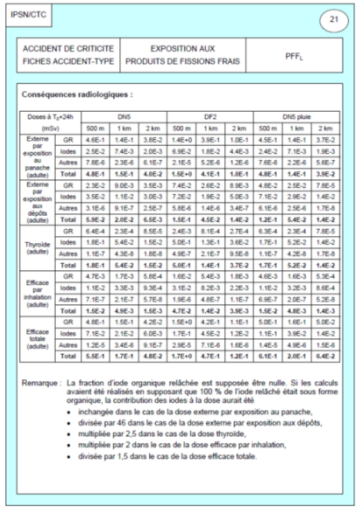


IRSN « Slide Rule »

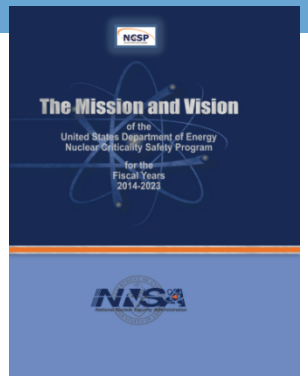
- 2000, IPSN « Slide Rule »
  - 2 internal reports:
    - Operational document
    - Annexes to operational document



- Objectives was to estimate:
  - Direct Neutron and gamma doses
  - Fission Product release dose (created by the accident)
  - Initial fissile material release dose



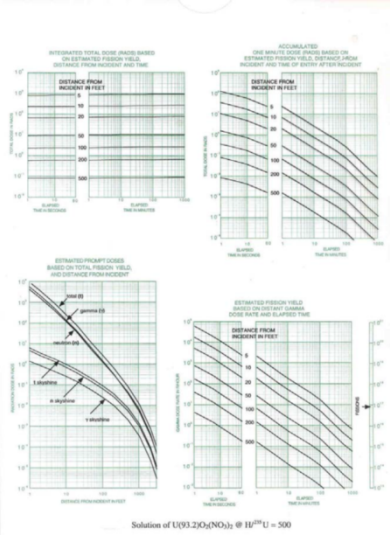
Long term DOE/NNSA NCSP – IRSN collaboration



- NCSP wants to develop and maintain modern SlideRule
  - LLNL-AM3 proposal (2015)
  - ORNL-AM6 proposal (2015)

Accident analysis:		Budget Priority / Technical Priority
Field-deployable emergency response methods on portable, handheld platform	Develop and maintain modern, accident analysis capability (SlideRule)	
3D accident analysis capability	Develop and deploy time-	

- IRSN wants to review and improve its slide rule
  - IRSN-AM5 proposal (2015)



- Proposal of a complete work, divided into several steps:
  - Step 1: Redo with modern radiation transport tools, for the same configurations and assumptions, the calculations performed initially for the 1997 estimation of the doses

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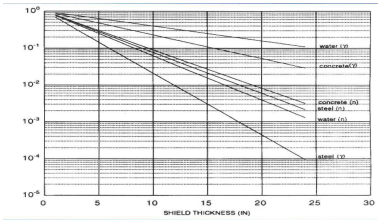
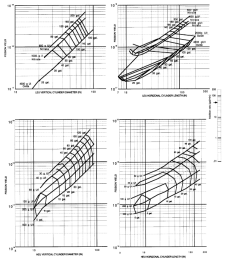
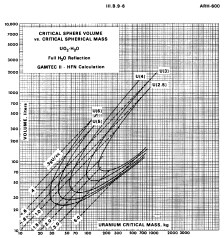
Long term DOE/NNSA NCSP – IRSN collaboration



- Step 2: Perform additional configurations/calculations
  - New configurations (new geometry of the source, new fissile media including plutonium systems, impact of multiple layers of shielding…)
  - New flux-to-dose conversion factors (for dosimetry, radiological protection and instrumentation purposes)



- Step 3: Review and improve the section regarding the estimation of the number of fissions



- Step 4: Add other sections to the document like a section regarding actions to stop an on-going criticality accident (for example, standards with neutron poison)

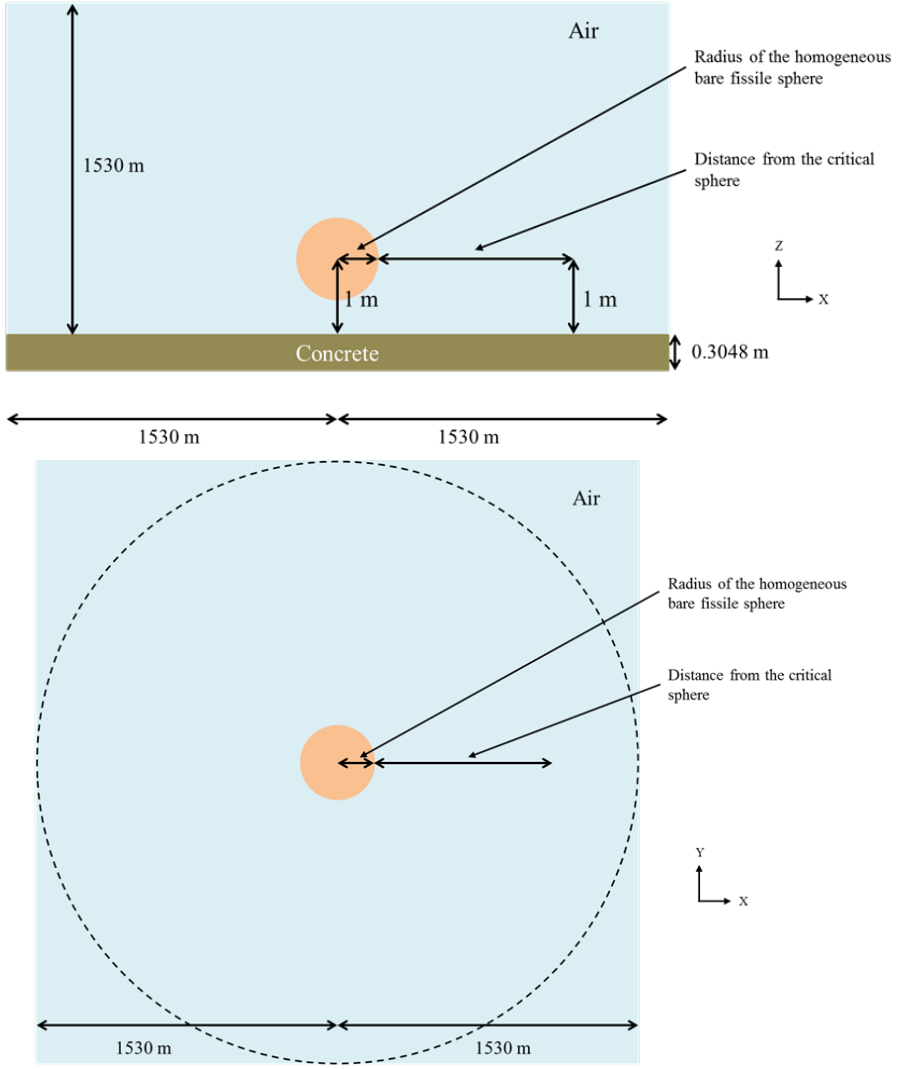
- Final step: Based on the previous work, development of a Slide Rule "application" for a handheld device (e.g. smartphone)

Step 1: Slide-Rule « Initial » Configuration

Geometry : One Air (sky) layer above a ~30 cm concrete layer (ground)

Source : Spherical uranium critical system – 1 meter over the ground

Dose Detection : 0.3 to 1200 meters between source and dose detection.



ICRS 13 RPSD 2016

October 3|6, 2016
Paris, France

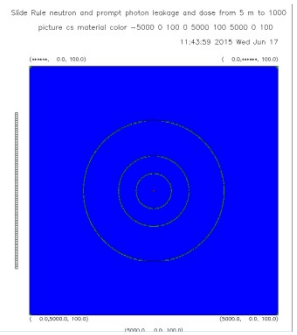
Step 1: Status and current works

- Since December 2014, IRSN has hired a contractor to work on this subject
  - Perform calculations with COG, MCNP and SCALE (and with ATTILA in the future)
- May 2015: COG installation and training (LLNL) @ IRSN
- June 2015: ATTILA training @ IRSN
- July 2015: NCSP FY2016 budget execution plan meeting @ Washington DC
- August 2015: MAVRIC training (ORNL) @ IRSN
- September 2015: 1st Slide Rule meeting @ Charlotte (ICNC)
- January 2016: Presentation of the first LLNL COG results @ LLNL
- February 2016: VTC with ORNL

→ October 2016: Submission of an article to ICRS-13/RPSD-2016
  - 13th International Conference on Radiation Shielding (ICRS-13) & 19th Topical Meeting of the Radiation Protection & Shielding Division of the ANS (RPSD-2016)

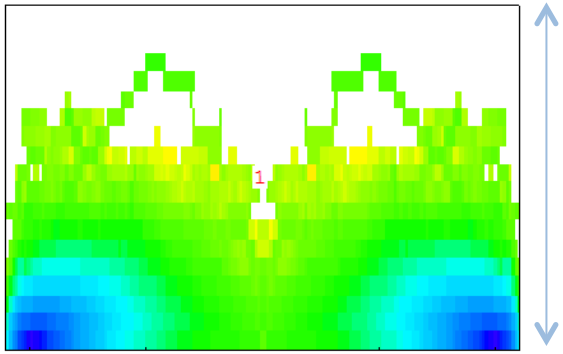
COG, MCNP, MONACO Models special feature

COG : Criticality Calculation Mode
K_{eff} and dose calculation in one calculation



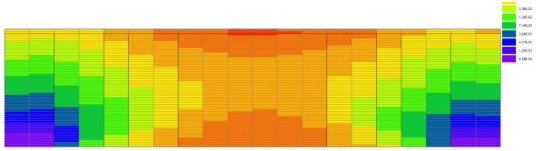
COG XY Cross-section of spherical source and toric detectors

MCNP :
First Step : KCODE (scoring fission rate)
Second Step : Fixe source calculation (ww biasing)



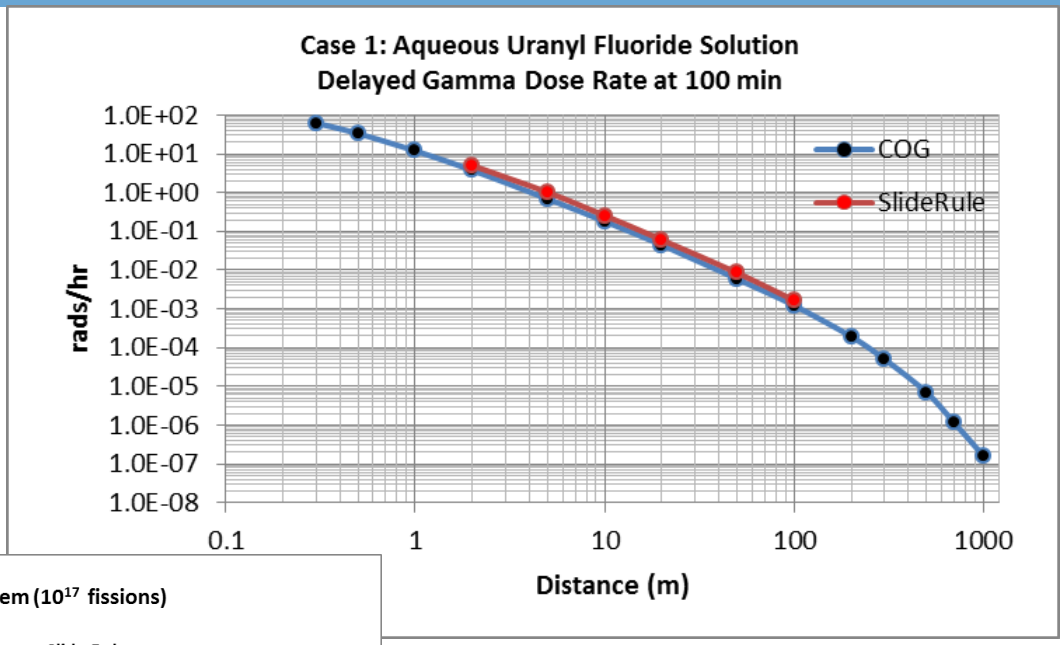
MCNP XZ Cross-section with weight window associated to 1000 m detection

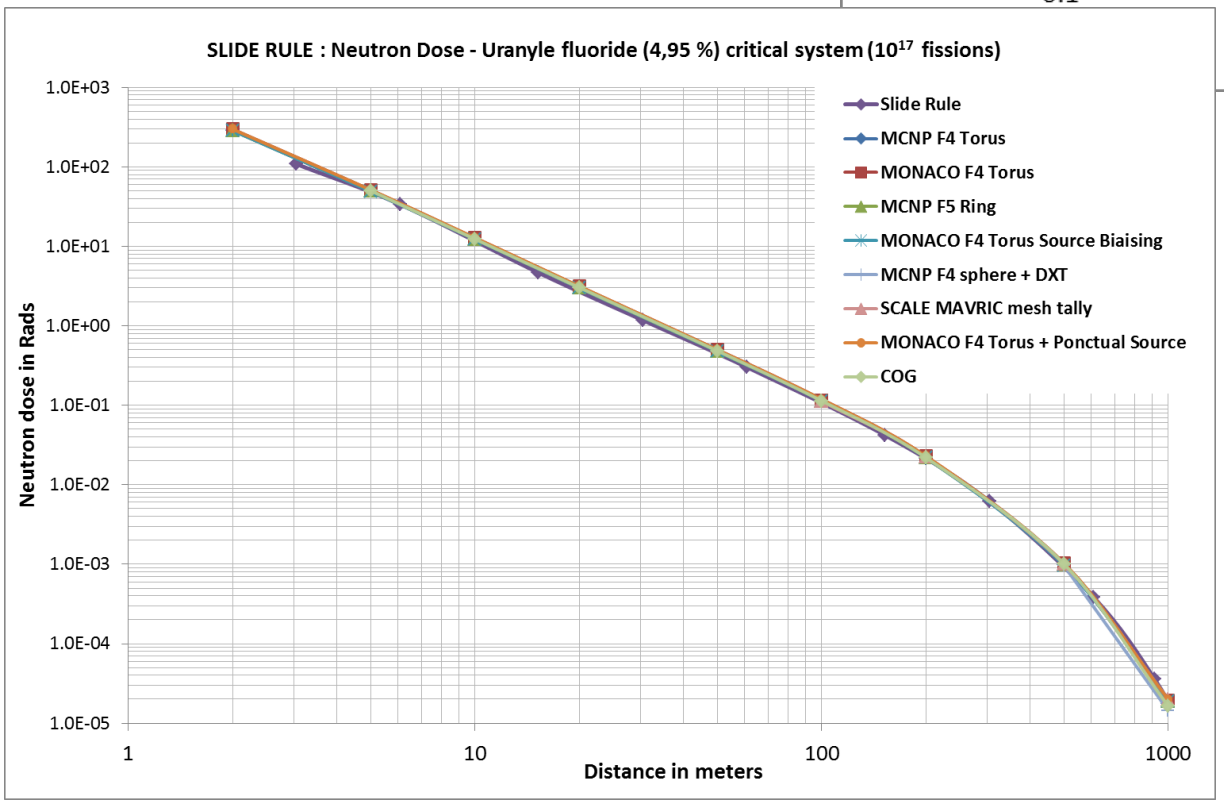
SCALE :
First Step : XSDRNPM (scoring leakage spectrum) or KenoVI (scoring fission rate)
Second Step : MONACO Fixe Source calculation (Denovo map of importance).



MONACO XZ Cross-section Denovo map of importance associated to 1000 m detection

Example of results IRSN / LLNL





Perspectives

- Step 1:
  - ICRS-13/RPSD-2016 article
  - Issue of a common report
- Step 2:
  - Discuss and validate the additional configurations
- Other steps:
  - Write a roadmap

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Thank you for your attention !!!

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